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SOILS OF THE EASTERN UNITED STATES AND THEIR USE—X.

THE MARSHALL SILT LOAM.

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SOILS OF THE EASTERN UNITED STATES AND THEIR USE—X.

THE MARSHALL SILT LOAM.

GEOGRAPHICAL DISTRIBUTION.

The Marshall silt loam is without doubt the most extensive single type of soil to be found within the limits of the United States. Extensive areas of this type have been encountered in 20 soil surveys distributed through seven different States, and an aggregate area of 4,084,230 acres of the type has thus far been mapped. The region within which this soil dominates practically all others extends from west-central Indiana through central and western Illinois across northern Missouri and southern Iowa and into central Nebraska and northern Kansas. Throughout this entire region the upland, brown prairies consist chiefly of this single soil type, and in certain counties of which soil surveys have been made within this prairie belt from 65 to 80 per cent of the total area has consisted of the Marshall silt loam alone. Sufficient soil surveys have been made through this section to outline the general region within which it may be expected that additional extensive areas of the Marshall silt loam will be encountered, and it may be predicted with safety that fully one-half of the total soil area within the region designated will ultimately be found to consist of this one type.

CHARACTERISTICS OF SOIL AND SUBSOIL.

The surface soil of the Marshall silt loam consists of a dark-brown, chocolate-brown, or almost black silt loam, which is evidently rich in organic matter. This surface soil varies in depth from 7 or 8 inches in the more rolling areas to 18 or 20 inches on the more level prairies. The average depth of the soil material is probably in the vicinity of 15 inches. The surface soil grades into a lighter colored, sometimes mottled, silty loam or silty clay, whose prevailing colors are yellow, gray, or drab, depending to some degree upon the completeness of subsoil drainage. This same class of material usually extends to a depth of 6 or 8 feet, in the more shallow deposits, to depths of 20 or 30 feet or even more, where the deposits are fully developed. Both surface soil and subsoil are unusually free from stone or gravel of any description, and even the coarser grades of sand are almost entirely

lacking. Not infrequently, however, there are found within the sub-soil concretions and accumulations of lime carbonate, and occasionally the limy remains of shells, principally of land forms of organic life.

The Marshall silt loam is derived from the extensive body of fine silty rock powder which overspreads a considerable proportion of the central prairie States, mantling the older rock formations and covering the underlying glacial till to varying depths. This silty material doubtless originated from the outpouring of turbid water through the melting of the glacial ice during one of the later stages of its recession. It was widely distributed over the central portion of the Mississippi drainage region, and there is good evidence to show that when the surface of this material became dried and powdery it was taken up by the winds and thus distributed even over the higher elevations of that region in the form of a thin mantle of loess. In fact the Marshall silt loam is one of several important soil types derived directly from the partial weathering of this loess mantle. It constitutes the brown prairie areas, stone free, and gently rolling to undulating in its characteristic surface features.

The Marshall silt loam and other soils of the Marshall series are thus distinguished from the soils of the Miami series, which are light colored and derived from the weathering of the glacial till, and also from the black soils of the Carrington series, which resemble it in color, but have also been derived principally from ice-laid materials. It is separable from the soils of the Knox series, which also owe their origin to the surface layer of loess, in that the latter are distinguished by light-colored surface soils and are found within the timbered areas as contrasted with the prairie areas in which the darker Marshall soils occur. The black soils of the Waukesha series usually occur to the northward of the regions occupied by the Marshall silt loam and its associates, and the Waukesha soils are derived from the coarser outwash laid down directly by the action of moving water.

The Marshall silt loam may be briefly characterized as the most important soil of that series, and as the brown to black silty prairie soil formed from the modification of the surface materials of the loess.

SURFACE FEATURES AND DRAINAGE.

Throughout its entire extent the Marshall silt loam is marked by nearly level, slightly undulating, or gently rolling surface topography. Only where the larger streams have cut deep trenches are sloping areas found within this type. These, even, are infrequent since the eroded and sloping bluffs of the loess along the stream drainage ways are most frequently timbered and possess the lighter colored surface soils, thus falling within the Knox series as contrasted with the Marshall. This fact of nearly level surface, or at the most of slight undulations, over large extents of territory has rendered the Marshall silt

loam one of the most prized of the general farming soils in the central prairie States.

In general the surface slopes are sufficient to give fairly adequate natural drainage without giving rise to erosion, except over small areas. In consequence the topographic features of the Marshall silt loam are such that fully 90 per cent of its surface may be cultivated with the heaviest and most complete equipments of labor-saving farm implements. This fact alone has placed the type of soil in great demand for agricultural purposes.

Within the States east of the Mississippi River where the Marshall silt loam is developed, its surface lies at altitudes ranging from 650 feet to approximately 1,000 feet above tide level. In northwestern Missouri and in southwestern Iowa the altitude rises gently to approximately 1,000 feet and the same altitudes prevail immediately to the west of the Missouri River in Kansas and Nebraska. It is only in the central portions of these latter States that the elevation of the Marshall silt loam attains to 2,000 feet or more above sea level. Thus the type extends in a broad east and west belt within the temperate region of the United States at altitudes prevailing between 650 feet and 1,500 feet above tide.

The development of the Marshall silt loam east of the Missouri River is entirely within a territory which experiences an adequate rainfall well distributed throughout the growing season, and there is thus no deficiency in the natural moisture supply for the production even of those crops which make the greatest demand for soil moisture during a long continued period of growth. West of the ninety-eighth meridian, however, the amount of rainfall rapidly decreases, and those areas in the extreme western region of the development of the Marshall silt loam sometimes experience insufficient rainfall for the production of such crops as Indian corn and oats. There is thus within the area occupied by the Marshall silt loam a gradation from a maximum rainfall in its eastern extent to a lighter rainfall, amounting to about 25 inches annually, at its extreme western limits.

In the earlier days when the central portion of the United States was first being opened for settlement the drainage conditions over a considerable part of the area mapped as Marshall silt loam were not adequate. During the months of spring and early summer the almost level prairie lands were frequently covered by standing water, which was only removed by percolation and evaporation during midsummer. The areas in consequence were occupied by rank growths of prairie grasses in the central States, and these were largely utilized for pasturage by the earlier settlers, who cleared their farms and built their dwellings near the stream courses within the timbered belt. With increases in population, with the opening up of sluggish stream channels, and particularly with the installation of extensive tile under-

drainage, this condition of poor drainage was rapidly removed. The land thus reclaimed was found to be even more productive than the timbered lands previously occupied. The cost of artificial drainage was usually low, since the ditches were easily dug in the stone-free soil and subsoil and in the majority of instances only a single line of tile laid through some depression or broader slough was necessary to remove the surplus water which had previously prevented crop production. The tile drainage of this type and of similar soil types in Ohio, Indiana, and Illinois has been accomplished through the laying of thousands of miles of drains at a cost estimated in various cases from \$10 to \$12 or \$15 per acre of the land drained, on the average, with maximum costs not much exceeding \$20 per acre. When it is considered that these very moderate expenditures have sufficed to bring under the most profitable cultivation millions of acres of land of the highest agricultural value, it will readily be seen that the drainage of this type has been one of the great engineering problems worked out by the American farmer for the betterment of his lands. Such drainage operations have not been required to any extent in areas of the type found west of the Missouri River. However, there still remain considerable areas of but partially drained land included within the Marshall silt loam in northern Missouri and portions of Iowa. Even where water does not stand through any portion of the year upon the surface soil, it is frequently the case that the installation of a moderate number of tile drains over fields occupied by this type will increase the depth of friable surface soil material, render the zone occupied by the roots of crops considerably deeper, and accomplish the certain production of excellent yields, both in seasons abnormally wet or unusually dry. Especially in such instances, which are rare, where small areas of "hardpan" are found between the surface soil and the subsoil is additional drainage to be recommended.

West of the Missouri River the higher elevation and somewhat steeper slopes found within the areas of the Marshall silt loam not infrequently give rise to incipient or even serious erosion along the margins of the type. Where this is the case, it is to be recommended that such steep areas should be established in permanent pasture grasses, and the areas should be used for the maintenance and grazing of beef cattle and dairy cows. The area of this type subject to destructive erosion constitutes but a very small percentage of its total extent.

LIMITATIONS OF YIELD.

The surface soil of the Marshall silt loam is so friable, so free from stone, so well granulated, and so nearly level that all of the crops suited to the climate and to a silty soil are grown to perfection upon it. The surface soil readily absorbs by far the greater proportion

of the moisture which falls upon it. This moisture is stored within the silty surface soil and maintained against downward percolation by the heavy silty loam or silty clay subsoil in sufficient quantity to satisfy the demands of such crops as Indian corn and oats, both of which require unusually large amounts of soil moisture for the production of maximum yields.

In addition the surface soil is unusually well supplied with partially decayed organic matter through the centuries of growth, death, and partial decay of the prairie grasses which flourished over its surface before agricultural occupation of the type was brought about. At present the drainage of the type is adequate over practically all of its extent. Erosion is not a serious problem, except in limited areas. The surface topography, the stone free character of the soil, the absence of timber, have all rendered its occupation and tillage easy. Thus the limitations upon the classes of crops which may be grown, and even the limitations upon the yields secured, are chiefly those of climatic surroundings and of efficiency in cultivation rather than those of the inherent properties of the soil itself.

Within the more eastern extent of the Marshall silt loam the annual precipitation amounts to 35 or 40 inches. This precipitation occurs in such form and at such times as to be absorbed readily by the soil and to be maintained for the ensuing growth of plants. The amount of precipitation gradually declines westward across the Missouri River, and only becomes deficient when the great dry-farming region of western Nebraska and Kansas is reached. This variation in precipitation, however, gives rise to variation in the kinds of crops which may best be grown upon different portions of the region occupied by the Marshall silt loam. In the more eastern sections the general farming crops common to the temperate portion of the humid region may all be grown to advantage. Westward from the Missouri River, however, certain special crops gradually replace the corn, wheat, oats, and grass of the more eastern region, and large areas of Kafir corn, of broom corn, of durum wheat, and of emmer are coming to be raised upon the Marshall silt loam in the central and western portions of Kansas and Nebraska. These crops, more resistant to drought and better suited to dry farming conditions, have permitted of the extension of profitable agriculture far beyond the limits which, half a century ago, it was supposed had been set by precipitation conditions upon the profitable agricultural occupation of the land. Similarly, the timothy and clover of the more humid region is largely displaced by increasing acreages of alfalfa grown upon the Marshall silt loam, as well as upon other types of soil west of the Missouri River. This valuable forage plant is coming to dominate the hay production upon the Marshall silt loam not only in this more western region, but even within the more humid portions of its development.

IMPROVEMENT IN SOIL EFFICIENCY.

The high value of the Marshall silt loam for the production of general farm crops has practically eliminated the production of special crops upon the type, so that any discussion of the limitations of soil efficiency must be that of the limitations upon the production of such crops as corn, wheat, oats, and hay. The high value of the type for the production of corn has led, not infrequently, and particularly in the earlier days, to the long-continued production of corn year after year upon this soil. For a long period of time practically no decreases in yield were observed, or where such occurred their cause was coupled with climatic difficulties rather than with the practice of the cropping system. Within later years, however, it has been recognized by the majority of farmers in the eastern portion of the central prairie States, both upon the Marshall silt loam and upon other soils, that adequate crop rotation constitutes one of the necessities for the maintenance of soil efficiency. In consequence crop rotations have been adopted over practically all the Marshall silt loam which is tilled in Indiana, Illinois, and the greater part of Iowa and Missouri. The most common rotation includes two or three years devoted to the production of corn, followed most frequently by a single year of sowing to oats or, to a limited extent, to wheat, succeeded by two or three years devoted to the growing of timothy and clover, of clover alone, or to an increasing extent, of alfalfa. With the adoption of such rotations the yields of corn have largely been restored to their former magnitude or even increased. This fact has been noted repeatedly during the progress of soil surveys over the territory described.

In the study of the Marshall silt loam in one of the Indiana counties where it has been extensively mapped, a sample of this soil was taken from a cultivated field which had been cropped continuously to corn for seven years with an average yield of 45 bushels per acre. The field had never been sown to clover nor had any fertilization of any kind ever been attempted. In the test of the manurial requirements of this soil sample, various fertilizing ingredients were applied to the soil singly and in different combinations. None of these treatments produced any appreciable increase in the growth of the plants. At the same time the plants used as indicators and grown both upon the treated and the untreated soil were of good size and of normal condition. This would indicate that thorough cultivation, the proper handling of the soil, coupled with an adequate crop rotation, is practically the only treatment of the type required for the maintenance of its efficiency.

It has also been noted in a number of areas that the production even of a single small grain crop between the periods when the fields were planted to corn has had a beneficial effect upon the succeeding

corn crops, thus showing the desirability if not the necessity of some form of crop rotation for the maintenance of the efficiency of the type.

LIMITATIONS UPON SPECIAL CROPS.

The high value of the Marshall silt loam for the production of corn, primarily, and of oats and hay in proper rotation with corn, has led to the devotion of almost all its area to the production of general farming crops. The financial results secured from this system of general farming have been so satisfactory that the introduction of any special crops upon the type has been undertaken only to a small extent in a few special localities.

It has been found that in the more rolling and elevated areas occupied by the Marshall silt loam, particularly in southwestern Iowa but also in other portions of the area where it is developed, certain varieties of apples may well be planted where both air and water drainage are adequate. These varieties are the Wealthy, Jonathan, Winesap, and Ben Davis. It is undeniably a fact that apple production upon a commercial scale over a considerable proportion of the area of this type east of the Missouri River is possible, and ultimately will become desirable when the demand for the varieties suited to it shall justify their extensive planting.

Locally Irish potatoes also constitute an important subordinate crop for production upon this type. The yields vary from 75 to 150 bushels per acre under the most ordinary treatment and could undoubtedly be doubled by anyone engaging in the systematic cultivation of the crop.

Locally the small fruits and garden vegetables are produced for home consumption, and in the vicinity of some of the larger cities within the area of the Marshall silt loam market gardening has been undertaken upon the type to some extent. This is notably the case in the vicinity of Omaha and of some of the other more western cities. In general, however, the type is at present devoted to its best uses as the great corn soil of the central prairie States.

EXTENT OF OCCUPATION.

Although somewhat neglected in the earlier days of pioneer settlement, the Marshall silt loam has latterly been occupied for agricultural purposes through practically its entire extent, and there are few soils within the United States which annually bear such a high proportion of tilled and cultivated crops as this soil. Throughout its extent, approximately 90 per cent of the Marshall silt loam may be classed as improved farming land. It is only in its extreme western development under conditions of scarcity of rainfall that any large area of the type is ever used for pasturage purposes. In such

areas the native prairie grasses are allowed to remain upon the type to furnish excellent grazing for herds of beef cattle.

The gentle slopes of the surface, the stone free condition of the soil, its considerable depth, its adequate supply of organic matter, and its excellent texture and structure, rendering tillage operations easy, have led to this complete and efficient usage of the Marshall silt loam.

The adoption of improved cultural methods within the dry farming areas of central Kansas and Nebraska has constituted the only wide extension of occupation which the Marshall silt loam has experienced during the past 40 or 50 years. Under these improved cultural methods, all of which tend toward the absorption and retention of atmospheric moisture for the use of plants, areas previously considered too dry for the production of crops are now rapidly being utilized for the production of sorghum, Kafir corn, broom corn, millet, emmer, alfalfa, and durum wheat. Under this occupation the last areas of native pasture grasses devoted to the ranging of cattle are disappearing.

CROP ADAPTATIONS.

The Marshall silt loam is the great, dominant, Indian corn-producing soil of the central prairie States. Throughout the region where it occurs from central Indiana to central Kansas and Nebraska the yields of this crop reported from the Marshall silt loam are not only above the yields reported from associated soil types, but they are so high that the counties principally covered by the Marshall silt loam are the premier corn counties of these States. In such counties as have been included in the soil surveys, where 50 per cent or more of the total extent of the county consists of this type the average yields of corn per acre, as ascertained from the census reports, range from 25 to 35 per cent above the average yields for the States in which such counties occur. In Indiana, Illinois, northern Missouri, and southern Iowa the yields of corn per acre in counties dominated by this type range from an average of 37 bushels to an average of 49 bushels per acre. Similarly in eastern Kansas and Nebraska where the rainfall is adequate for maturing large yields of Indian corn, the average yields of this crop in counties dominated by the Marshall silt loam range from 35 to 40 bushels per acre. Even in more western counties, where the rainfall is supposed, popularly, to be inadequate for corn production, yields of 25 to 30 bushels per acre are secured. In all cases it may be asserted without fear of contradiction that the corn yields upon the Marshall silt loam throughout its extent exceed the yields secured upon any other single extensive soil type. In fact a large proportion of the annual corn supply of the United States is secured from States and counties where corn production is principally developed upon this soil.

In Illinois the yields of corn upon the Marshall silt loam have been stated in the various soil survey reports to range from 40 to 80 bushels per acre, and it is probable that the average yield for the type within the State will be in the neighborhood of 50 bushels per acre. In Indiana, corn yields from 40 to 60 bushels with an average near the 50-bushel mark for this type. In Iowa the yields are practically the same and the average is maintained at 47 to 50 bushels. In Kansas the range is a little wider owing to variations in climatic conditions, and the yields are stated at 25 to 50 bushels with an average in the vicinity of 35 bushels per acre for the Marshall silt loam. In northern Missouri the yields range from 30 to 80 bushels per acre with an average yield for the Marshall silt loam in the vicinity of 40 bushels. The yields in Nebraska are almost identical with those in Kansas for similar climatic conditions.

Thus, both the high average yield per acre and the extremely wide development of the Marshall silt loam mark the type as the dominant corn soil of the great "Corn Belt."

Many different varieties of the dent corn are grown, and each locality possesses favorite varieties which have been proved by experience to be well suited to the attendant climatic conditions and to be well suited to production upon this soil.

Oats constitute the principal small-grain crop grown upon the Marshall silt loam east of the Missouri River. The oats are seeded upon the land previously occupied by corn, upon the "stalk land," as the prairie farmers designate it. The acreage devoted to oats is considerably less than that devoted to corn, but the yields are in all cases excellent. It is practically a universal observation in the soil surveys which have included large areas of the Marshall silt loam in the Central Prairie region that the yield of oats per acre is usually about the same average yield as that of corn, thus ranging from 40 to 60 or 70 bushels per acre with an average from 45 to 50 bushels in the more humid sections.

In the region lying upon both sides of the Missouri River from central Missouri west through eastern Kansas and Nebraska, winter wheat constitutes the dominant small-grain crop and occupies the same place in the crop rotation that is occupied by the oats farther east. In Iowa the average yield of wheat upon the Marshall silt loam is about 16 bushels per acre. In central Missouri it is 12 to 15 bushels per acre, while in eastern Kansas and Nebraska wheat will average from 10 to 15 bushels per acre. Farther west in these latter States the wheat yield sensibly declines, until an average production of 8 to 12 bushels is considered about the normal yield of winter wheat upon this type. The ordinary varieties of winter wheat in this drier portion of the area are being replaced by the durum wheat, a summer grain, which is better suited to production under dry farming conditions. Its

yields per acre are considerably greater, ranging from 15 to 20 bushels or even more. Thus the climatic factors rather than the inherent fertility of the type tend to determine not only the varieties of wheat and other crops which may be produced, but also to a large degree impose a maximum limit upon the yields per acre.

Mixed timothy and clover, or clover alone, are the grasses principally seeded upon the Marshall silt loam east of the Missouri River. These grasses are most frequently seeded with the oats and are allowed to remain upon the land from one to three years. In the latter case the area in grass is usually devoted to pasturage during the third year. The yields of grass are satisfactory, but not abnormally high, ranging from $1\frac{1}{4}$ to $1\frac{1}{2}$ tons for the averages in the counties where the Marshall silt loam dominates. The yields of the type are somewhat higher than this, averaging from $1\frac{1}{2}$ to 2 tons per acre, and not infrequently exceeding the latter figure. Within recent years, particularly in Illinois, the introduction of alfalfa has made rapid progress on the Marshall silt loam. Wherever the subsoil drainage of the type is adequate and wherever inoculation with the proper bacteria is secured, either naturally or artificially, the crop thrives upon the Marshall silt loam. Yields of $2\frac{1}{2}$ to $3\frac{1}{2}$ tons per acre are frequently secured in three cuttings, and yields of 4 or 5 tons per acre have been obtained when the utmost care in the preparation of the land and in the seeding of the crop was observed. It is in the more western portions of the territory occupied by the type, however, that alfalfa has occupied the dominant place in hay production. In central and western Kansas and Nebraska alfalfa has been seeded over thousands of acres of the Marshall silt loam and four or five cuttings are secured each year with yields ranging from $3\frac{1}{2}$ to 5 tons per acre per annum. The soft silty surface soil, the well-drained subsoil, and the calcareous nature of the subsoil furnish fundamental requirements of the alfalfa plant. In many instances artificial inoculation is found to be unnecessary, although it is to be recommended if there is any uncertainty in regard to the natural inoculation of the fields. The extension of this very valuable forage crop upon the Marshall silt loam in all the areas where it occurs is to be highly recommended.

These constitute the dominant crops raised upon the Marshall silt loam. In addition, emmer, sorghum, and millet are produced as forage crops, and Kafir corn and milo maize are grown, both for the grain and for the fodder. Broom corn is grown only in the more western areas where the type has been encountered, although this is an important crop in some portions of Kansas.

The lack of any systematic crop rotation upon the prairie farms occupied by the Marshall silt loam has already been noted. In the earlier days this lack was general. At the present time more and

more attention is being paid to crop rotation in the more eastern sections where the type occurs. In general the rotations have been worked out by natural selection and by the elimination of unsuitable crops from the farm practice. The first obstacle to the wider introduction of rational crop rotations lies in the not unnatural desire to produce as many crops of corn as possible and to devote the largest possible acreage of this soil type to maize production. As a result there has naturally been built up in the best farming sections, upon the Marshall silt loam, a crop rotation which ordinarily consists of the production of two or three crops of corn in succession, followed by a crop of oats, sown upon the "stalk land" in the spring. With the oats, either timothy and clover are seeded in or clover alone. After the removal of the oat crop the grass is allowed to occupy the land for two years or at the most for three, when the sod is plowed and several corn crops are again planted in succession. In the majority of instances in Indiana, Illinois, and the eastern portions of Iowa and Missouri this rotation is adequate and well suited both to the soil and to the agricultural necessities.

This rotation is modified in southwestern Iowa and northwestern Missouri by the production of larger areas of winter wheat and smaller areas of oats. In this instance the winter wheat merely takes the place of the oats in the rotation, although in some instances the seeding to grass is also omitted, and the rotation becomes a mere alternation of two or three crops of corn, succeeded by a crop of wheat. Under this latter practice the yields of either grain are maintained only with difficulty.

West of the Missouri River the omission of crop rotation is frequent, and corn is raised successively as long as an adequate crop may be secured. Then wheat is sown for several years in succession until yields are reduced, and a return is made to corn growing. This practice is rapidly passing away and systematic crop rotation is taking its place with marked benefit, as shown by increased yields.

Very little commercial fertilizer is used in any locality for any purpose upon the Marshall silt loam, and in some localities which it dominates the use of fertilizers is decreasing rather than increasing. In too many instances the application of stable manures is neglected and the numerous streams which intersect the prairie section of the more western States are used as the depositories for this material. This is a serious waste and one which should not occur under any well-regulated system of agriculture. In fact the application of stable manures is usually marked by increased crop yields and by a greater certainty of producing the crop, especially under conditions of moderate drought.

Fruit crops.—Only in a few localities has the Marshall silt loam been utilized as an orchard soil. The notable exceptions to this occur prin-

cipally in the more rolling areas of the type found near the courses of some of the larger streams, particularly in southwestern Iowa and in northwestern Missouri. In this section considerable horticultural development has occurred within the last few years and commercial plantings of apples have been made upon this type. The red varieties are usually planted, and Wealthy, Jonathan, the Winesaps, and Ben Davis have been set out in considerable acreage. The trees make good growth, especially when the land is properly tilled and a sufficient mulch is maintained to protect the soil from excessive evaporation. The trees come to maturity early and produce paying crops at from 8 to 10 years from the time of planting. The results which have been accomplished in these localized areas serve to indicate that all of the higher lying and more rolling portions of the type within the humid region may be utilized for the production of orchard fruits whenever the farming communities desire to vary their agricultural practice from grass and grain production.

A wide variety of vegetable crops may be produced to advantage upon the Marshall silt loam, but over most of the territory occupied by the type their production thus far is principally confined to the raising of the home supply, and only in the immediate vicinity of the larger cities has any attempt been made at market gardening. Irish potatoes, cabbages, onions, and many other vegetables may be grown to advantage upon the type, while small fruits, pears, and grapes are produced upon a small scale in satisfactory quantity and of excellent quality.

In the more northern regions where the Marshall silt loam is developed the growing of sugar beets might well be extended from its present localized areas, to become an important adjunct of the existing cropping system. The lack of a cheap and adequate supply of labor has constituted the principal factor limiting the growing of this crop, although beet-sugar factories have been established at a few points where the type might thus be utilized. The tonnage secured varies from 8 to 12 or 15 tons per acre, and the purity and sugar content of beets grown upon this soil are both satisfactory.

Although a large part of the corn and of the small grains produced upon the Marshall silt loam finds its way to the elevator and to market, still an increasing amount of the corn and oats is being fed to beef cattle and to dairy stock and hogs, particularly in the central and eastern States, where the soil type is developed. In Iowa particularly dairy industry has taken a firm hold upon the agriculture of the area occupied by the Marshall silt loam. Corn is not only raised for grain production but also for silage purposes, and the oats are fed both to the work stock and, ground with other grains, to the dairy cows. The mixed timothy and clover hay is utilized as roughage in the feeding ration, and frequently the areas in grass are pastured dur-

ing the final year before the sod is ultimately plowed for corn production. Under this system dairy cows are cheaply and adequately fed, and a large production of butter results in Iowa and in adjoining portions of Illinois and Wisconsin. The feeding of beef cattle is quite general both in the central and western prairie States where the Marshall silt loam is developed. Particularly in the more western areas this form of animal industry takes precedence over dairying. It is especially prevalent where some portions of the type and of other associated soils remain in the native prairie grasses and are utilized for grazing, while the corn is fed to the cattle to finish them off for market.

FARM EQUIPMENT.

In general, the equipment of teams and tools employed in the cultivation of the Marshall silt loam is adequate. In fact, over a greater proportion of the type the 4-horse hitch, with each animal weighing from 1,250 to 1,500 or even 1,600 pounds, constitutes the normal farm equipment. Areas ranging from the quarter section (160 acres) to the full section, or even more, are operated by heavy teams and power machinery with the intervention of only the smallest possible amount of human labor. The surface configuration of the type, its freedom from stone, its favorable textural and structural condition, and the considerable areas included within a single farm all render this type of tillage both desirable and economical. In many instances the old turning plow, requisite in the earlier days for breaking the tough prairie sod, is now used only for the purpose of breaking the sod formed by the tame grasses in regular rotation with other crops. In its place the 3-blade disk plow or even the disk harrow are used for preparation of the stalk land for the planting of corn or the seeding to oats. A thorough stirring of the surface soil results without the compacting of the subsoil at plow-sole depth. A considerable economy in the rate of plowing and the cost of preparation of the land is also secured by this practice over that which is possible in the use of the turn plow. The check-row corn planter, the riding cultivator, horse-power harvesting machinery, and other effective and heavy implements are almost universally employed upon the areas of the Marshall silt loam.

The buildings are adequate, usually including a well-built and well-painted farmhouse. Barns, both for the accommodation of the work stock and dairy or beef cattle, and some form of domestic water supply, are commonly seen in connection with the Marshall silt loam. Thus the farm equipment of the type is far above the average of that found upon the majority of farms or of soil types in the United States.

SUMMARY.

The Marshall silt loam is the most extensive single soil type known to exist in the United States.

It possesses a dark-brown silty loam surface soil, underlain by a yellow or mottled silty loam or silty clay subsoil.

It constitutes the dominant brown prairie soil extending from west-central Indiana across central and northern Illinois, northern Missouri, southern Iowa, and through eastern and central Kansas and Nebraska.

It is derived from finely divided silty mineral material, primarily of glacial origin, but distributed over its present locations largely through the moving agency of the wind. This material is known as the loess.

Its surface is level to undulating or in some cases gently rolling.

In altitude it extends from about 650 feet above sea level in Indiana and Illinois to altitudes above 2,000 feet in the central and western portions of Kansas and Nebraska.

At present the Marshall silt loam is adequately drained through the installation of thousands of miles of tile drains which have been used to supplement the partially established natural drainage of the type, particularly in eastern and central portions of its development. In the more western areas its natural drainage is adequate.

The Marshall silt loam lies chiefly within the humid region of the temperate portion of the United States, although its western extension occupies a large portion of the dry-farming region of central and western Kansas and Nebraska. This variation in rainfall condition, attendant upon the wide extent of the type, constitutes the dominant factor in the variation of its crop adaptations and yields.

The Marshall silt loam, both in average yield per acre and in its wide extent of territory, constitutes the dominant Indian-corn soil of the central prairie States and of the United States.

In addition, oats in the more eastern portion, wheat in the central and western portion, and the cultivated grasses universally, constitute important crops and the crop rotations generally adopted for the type consist of several crops of corn followed by one of the small grains, in turn succeeded by grass.

Farther west, under dry-farming conditions, Kafir corn, milo maize, broom corn, emmer, alfalfa, and durum wheat are produced.

Special crops aside from these mentioned are not produced to any extent upon the Marshall silt loam, owing principally to its high value for the production of the general farm crops.

Certain varieties of apples may be grown on the more rolling areas of the Marshall silt loam.

Both beef cattle and dairy cattle and hogs are extensively maintained upon the farms chiefly occupied by this type, and the great dairy industry of northern Illinois and of Iowa and some portions of Wisconsin is largely based upon the Marshall silt loam and the crops produced upon it.

The economical operation of the farms composed of this type is made possible by the use of heavy horses and a full equipment of modern power machinery, eliminating as far as possible the element of human labor. The equipment of buildings and of other accessories is also adequate throughout the greater portion of the area occupied by the type.

Probably 90 per cent of the total area of the Marshall silt loam is occupied by farms, and of the territory thus occupied by far the greater part, undoubtedly exceeding 90 per cent of the farm lands, may be classed as improved land occupied by some form of cultivated crop.

The acreage value of farms principally occupied by the Marshall silt loam ranges from \$35 to \$50 in its most western extension to \$75 or \$125 per acre in its more central portion. In the regions of central Indiana and Illinois, where the type has been occupied for upwards of 75 years, values rise to \$150 and \$200 per acre.

The Marshall silt loam, both in area and in economic efficiency, is one of the most valuable soils to be found in the United States.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., May 20, 1911.

APPENDIX.

The following table shows the extent of the Marshall silt loam in the areas surveyed to this time.

In the first column is stated the particular soil survey in which the soil was encountered; in the second column, its extent of development in acres; and in the third column, the volume of the Field Operations of the Bureau of Soils in which the report upon the area may be found. Those desiring a detailed description of the soil and of the general conditions which surround it in any particular area may consult these volumes in almost any public library.

Areas of Marshall silt loam encountered in the soil survey.

Survey.	Area of soil.	Year of publication, Field Operations.	Survey.	Area of soil.	Year of publication, Field Operations.
Illinois:	<i>Acres.</i>		Missouri:	<i>Acres.</i>	
Clinton County ¹	57,472	1902	Atchison County.....	208,896	1909
Knox County.....	289,088	1903	Cooper County.....	3,968	1909
McLean County.....	574,720	1903	Saline County.....	306,816	1904
Sangamon County.....	332,224	1903	Nebraska:		
St. Clair County ¹	106,432	1902	Grand Island area.....	137,984	1903
Winnebago County.....	90,624	1903	Kearney area.....	322,688	1904
Indiana:			Lancaster County.....	362,240	1906
Greene County.....	2,686	1906	Sarpy County.....	39,232	1905
Tippecanoe County.....	140,166	1905	Stanton area.....	102,720	1903
Iowa:			Wisconsin:		
Tama County.....	308,288	1904	Viroqua area.....	20,864	1903
Kansas:					
Brown County.....	307,264	1905			
Riley County.....	39,808	1906			

¹ Mapped as Miami silt loam.





